NASA STTR 2014 Phase I Solicitation

T12.04 Experimental and Analytical Technologies for Additive Manufacturing

Lead Center: MSFC

Participating Center(s): ARC, GRC, JSC, LaRC

Additive manufacturing is becoming a leading method for reducing costs, increasing quality, and shortening schedules for production of innovative parts and component that were previously not possible using more traditional methods of manufacturing. In the past decade, methods such as selective laser melting (SLM) have emerged as the leading paradigm for additive manufacturing (AM) of metallic components, promising very rapid, cost-effective, and on-demand production of monolithic, lightweight, and arbitrarily intricate parts directly from a CAD file. In the push to commercialize the SLM technology, however, the modeling of the AM process and physical properties of the resulting artifact were paid little attention. As a result, commercially available systems are based largely on hand-tuned parameters determined by trial and error for a limited set of metal powders. The system operation is far from optimal or efficient, and the uncertainty in the performance of the produced component is too large. This, in turn, necessitates a long and costly certification process, especially in a highly risk-aware community such as aerospace.

This topic seeks technologies that close top technology gaps in both experimental and analytical areas in materials design, process modeling and material behavior prediction to reduce time and cost for materials development and process qualification for SLM:

- Additive Manufacturing Technologies: Develop real-time additive manufacturing process monitoring for real-time material quality assurance prediction; Finish inspection and qualification of parts for implementation, replacement, and repair; Develop standards for accepting additively manufactured parts for use in space systems.
- Research-grade test beds: Experimental test beds that will allow for detailed study of individual phases of the SLM and other methods of additive manufacturing by NASA scientists, academic groups, etc. (Affordability of test bed will be crucial for fostering a large community of developers for next-generation SLM/AM systems.)
- Physics-based models: Reduced-order physics models for individual phases of additive manufacturing techniques, mainly to enable rapid processing of process data and to facilitate model-based optimal process control. (Note that most, if not all, phases of the SLM cycle requires coupled multi-physics modeling.)
- Analytical Tools: Develop analytical tools to understand effects of process variables on materials evolution to insure expected material microstructure and apply to certification of manufacturing process.
- Digital models: Standardize the use of structured light scanning or equivalent within manufacturing processes; model-based design environment where manufacturing does not rely on both models and drawings for data; standard paperless manufacturing execution system; digital fabrication machines that combine additive, subtractive, and other multi-axial material transformation processes.
- Numerical simulation codes: Software for high-fidelity simulation of various SLM phases for guiding the development, and enabling the subsequent verification, of new analytical physics models.

Mission Traceability - STMD continues to seek manufacturing techniques and capabilities that will allow missions of increased capability and reduced costs. Manufacturing technologies have high value and make a significant contribution to the interests of others outside of NASA, specifically those that address broader national needs as well as the needs of the commercial space industry.

State of the Art - Advanced Manufacturing is rapidly evolving, and newer technologies are emerging. The first in-space 3-D print experiment will fly in 2014, and related technologies will follow exponentially.